TESTIMONY of

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WATER RESOURCES AND THE ENVIRONMENT

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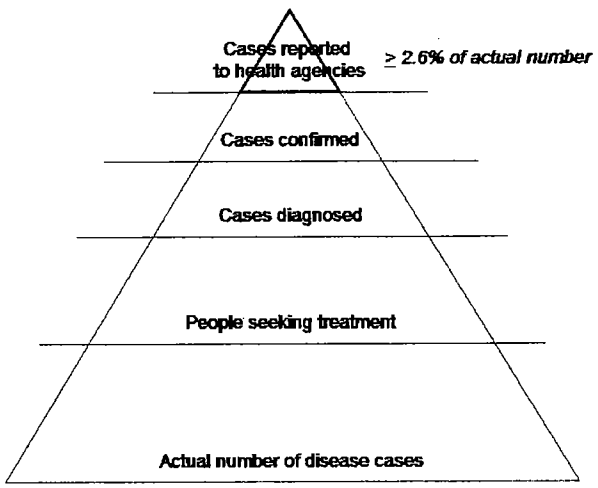
Good afternoon, Madam Chairwoman and members of the Committee. My name is Erin Lipp; I am an associate professor in the College of Public Health at the University of Georgia. I am an environmental and public health microbiologist. My research is focused in the area of water quality microbiology and ecology of waterborne pathogens. For the past decade I have been involved in issues associated with pathogenic bacteria and viruses in sewage impacted natural waters in the southeast United States, including rivers, streams, estuaries, and coastal and coral reef waters. I appreciate the opportunity to provide this Committee with scientific evidence about the role of untreated sewage in the introduction of harmful pathogens to our natural waters, and the potential for human illness resulting from contact with such contaminated water.

The scientific literature shows abundant evidence of the role of contaminated water as a source of infectious disease. According to the Centers for Disease Control and Prevention's (CDC's) most recent reports, there were 62 outbreaks of disease associated with recreational water and 30 outbreaks associated with drinking water reported between 2003 and 2004 [2,6], affecting a reported 5,400 people; however, this is likely a considerable underestimation of the actual numbers of people who became ill.

Among reported waterborne disease outbreaks in the United States the majority of outbreaks and cases were due to gastrointestinal illness [2,6]. While the burden of such reported waterborne diarrheal disease is high, it is widely recognized that these illnesses are vastly under-reported. Of the millions of people that likely contract a diarrheal illness, a small percentage seek medical treatment (~12% [3]), of this group a smaller percentage is actually diagnosed with a disease (or pathogen) and an even smaller fraction is then reported to state or local health departments. Finally, of those only a small number of diagnoses are eventually confirmed by laboratory tests. The end result is that as few as 2.6% of typical waterborne disease cases, causing mild to moderate gastroenteritis (vomiting and/or diarrhea) ever appear in state or federal databases (from Mead et al. [11], who reported that diarrheal diseases may be under-reported by as much as 38-fold). We are truly only seeing the tip of the iceberg in terms of disease burden (see figure below).



Exposure to water that may contain untreated human or animal waste, whether through drinking or recreational contact (swimming), can cause a wide range of diseases including gastrointestinal illness (i.e., diarrhea and vomiting), but also myocarditis, paralysis, hepatitis, dermatitis, ear infections, eye infections and respiratory infections. The severity of these illnesses can be quite varied from mild 24-hour 'stomach virus' to severe dehydration and death. Furthermore, certain segments of our population (for example young children, the elderly and the immune compromised) may be at significant risk from these waterborne diseases. Among the over 900,000 hospitalizations for gastrointestinal illness (from any source, including water [11]) that occur annually in the United States, 25% (~225,000) are children between the ages of 1 and 4 and the elderly (>80 years old) [4]. Furthermore, of the 6,000 deaths attributed to gastrointestinal illness [11], 85% occurred among those over 80 years old [4].

Hundreds of types of pathogenic bacteria, viruses, protozoa and other parasites are known to occur in human feces and untreated sewage. Furthermore, many microbes that are pathogenic to humans are also found in feces and carcasses of domestic and food animals, and slaughterhouse sewage is also commonly received at many wastewater treatment plants. Pathogenic agents and their concentrations in sewage are therefore reflective of the infectious diseases circulating in a population at a given time; in other words sewage contains those microbes that come directly from infected people (or animals in the case of slaughterhouses) in the community. The following agents of infectious disease are commonly detected in untreated sewage and are also implicated in waterborne disease:

- Bacteria including *Salmonella, Shigella, Campylobacter, Legionella,* and *E. coli* (including enterohemorrhagic strains). *Salmonella*, which remains one of the top causes of bacterial associated diarrhea in the U.S., has been estimated to occur at levels around 2,500 cells per liter of raw sewage [5].
- Protozoan parasites including *Cryptosporidium*, *Giardia* and *Cyclospora*. *Cryptosporidium*, which is the top cause of waterborne disease outbreaks in treated water due to its very high resistance to chlorination, was found to occur in raw sewage at a mean concentration of about 5,000 oocysts (infectious stage) per liter, and was found at levels reaching over 13,500 oocysts per liter [10].
- Viruses including enteroviruses (echoviruses, coxsackieviruses, poliovirus), rotavirus, hepatitis A virus, norovirus and adenoviruses. There is a wide range of concentrations of different viral types in sewage and these often vary seasonally (again reflective of the seasonal nature of many viral diseases); however, studies generally show the following range:
    - Rotaviruses (common cause of childhood diarrhea): >50 – 5,000 per liter[9,12]
    - Enteroviruses (common cause of childhood and adult gastrointestinal disease): 100 – 12,000 per liter [9,14,16]
    - Noroviruses (most common cause of adult gastrointestinal disease and notorious as the 'cruise ship virus'): 10,000 – 10,000,000 per liter [8,9]

Risk of disease varies by microbe but in the case of enteric viruses (such as noroviruses) and protozoan parasites (such as *Cryptosporidium* and *Giardia*), as few as one to ten organisms can cause disease in humans. This means that even a highly diluted sewage spill may contain an infectious dose of these agents. For example, assuming 10,000,000 noroviruses per liter of sewage (as described by Lodder et al. [8]), if the sewage was diluted during an overflow by 99.999% (for example, a 1 quart container of sewage emptied into a body of water the size of a typical backyard swimming pool) the final concentration would only be reduced to 100 viruses per liter (only ~30 per liter would be required to cause disease during swimming exposure; or one virus per 32 ml (2 tablespoons) of water that is ingested on average while swimming).

A large number and variety of pathogenic microbes are known to occur in untreated sewage; however, current regulations require that utilities and regulatory agencies monitor for only a small subset of microbes. These so-called fecal indicator bacteria, typically fecal coliform bacteria and enterococci, are not truly pathogens but are used, as their name implies, to indicate the presence of fecal matter and bacteria, viruses and protozoa that *are* pathogenic. While the use of this system has certainly aided in measuring and protecting water quality, they are not effective proxies for many of our most important waterborne pathogens, including viruses and protozoa, which are much more resistant to standard treatment practices and can persist longer once in the environment. For example, my own research in coastal Florida and Georgia has demonstrated that beaches and offshore waters that receive minimally treated sewage and are within the acceptable state and/or federal limits for fecal coliform bacteria or enterococci are frequently contaminated with enteric viruses (including enteroviruses, norovirus and adenoviruses). Yet outside of research studies, we have little widely applicable data on the occurrence (and associated risk) of specific human pathogens in our source water for drinking or our water used for swimming, fishing, or other recreational activities.

Given the lack of specific testing for pathogens, the lack of consistent reporting of sewage overflows, and/or lack of communication between regulators and health agencies, there are few studies that have been able to relate specific health outcomes or disease outbreaks with known sewer overflows. However, some data do exist and projections can be made.

- Drinking water:
  A detailed analysis of outbreaks due to drinking water in the U.S. published in 2002, documented that overflow or seepage of raw sewage was the number one known cause of illness associated with water obtained from untreated wells (groundwater) [1].
- Recreational Water
  In terms of general outcomes and risks associated with contaminated swimming waters, the table below shows the relative risk to public health associated with sewer overflows during dry and wet conditions; this was adapted from a study in coastal Australia [15].

In an example from my own work, extensive degradation of sewer lines in Key West, Florida, led to leakage of sewage into waters surrounding the island in the summer of 1999. During that time over 300 swimmers participated in a 12+ mile race around the island; exposure to that diluted sewage resulted in 30% of the swimmers becoming ill with eye, ear, nose or gastrointestinal infections [17].

Concern	Observation			
	Ambient dry weather conditions (no sewer overflow)	*Stormwater run-off during wet weather (no sewer overflow)*	*Wet weather with sewer overflow*	*Dry weather with sewer overflow*
Risk to public health from enteric bacteria and viruses	None	Low risk from human fecal contamination	Unsafe for recreation during overflow	Extremely high, reflecting very little dilution
Loss of amenity for recreational activities (including aesthetics)	None	Low risk from human fecal contamination	High during overflow	Extremely high

In addition, the impacts of sewage on our aquatic resources should not be ignored, but from a microbiological perspective there are even fewer data available. However, at least in the case of our remaining coral reefs, our most unique coastal resources, land-based pollution, including microbes, nutrients and organic matter from sewage contributes to decline and disease of coral reefs[7, 13].

Notifying the public in the case of a sewer overflow is in the spirit of the *Clean Water Act* goals, which ensures that our nation's waters are fishable and swimmable. Furthermore, given the current lack of communication and data collection on specific pathogens (or other constituents of sewage) there is a clear need to document the effects of sewage spills. To best protect both our public's health and our aquatic resources it is critical that we answer the following: 1) what is in the water? 2) in what concentration?, 3) who (or what, i.e., coral or other aquatic resource) is getting sick? and 4) how can agencies work together to minimize exposure and prevent disease? Implementation of a standard notification process coupled with coordinated data collection will help to address these issues.

In closing, I would like to note the following:

- Efforts to protect our nations interconnected waterways and coastlines is a laudable and *achievable* goal.
- In addition to public notification of sewer overflows, increased data collection on specific pathogens in our water and surveillance of associated diseases, especially among our most vulnerable populations, is needed.

- Additional research and regulations should support improved water quality guidelines to encompass the array of pathogens that threaten human and ecosystem health.

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